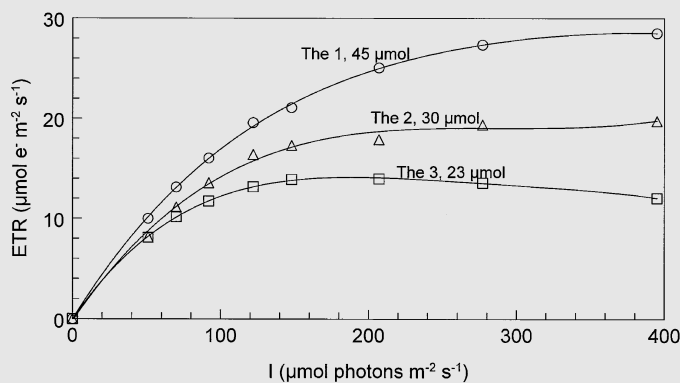


A new technique for non-intrusive *in situ* measurements of symbiotic photosynthesis

Symbiotic algae are instrumental in reef function and primary production by providing their invertebrate hosts with organic carbon required for metabolism and growth, and by enhancing calcification (e.g. Barnes and Chalker 1990). The methods most frequently used for quantifying photosynthetic rates of photosymbiont-containing reef inhabitants are based either on measurements of ^{14}C incorporation or O_2 evolution (Falkowski and Raven 1997). Although these methods can be applied *in situ*, they require that the organisms, or parts of them (e.g. detached coral branches), be unnaturally confined to enclosures for some time.

Pulse amplitude modulated (PAM) fluorometry, in combination with the saturating-light method, has been used for estimating effective quantum yields of photosystem II (Y) in terrestrial plants by measurements of chlorophyll fluorescence (see Schreiber and Bilger 1993 for a review of the technique). Introduction in 1997 of the first underwater PAM fluorometer (Diving-PAM; Walz, Germany), enabled the application of this method for *in situ* aquatic measurements of various photosymbiont-containing marine invertebrates (Schreiber et al. 1997) including corals (Beer et al. 1998) and sponges (Beer and Ilan 1998). The foremost advantage of using the Diving-PAM for underwater photosynthetic measurements lies in the method's non-intrusive nature. The organisms examined remain attached to their natural growth site, with no need to detach them or to confine them to chambers (Fig. 1; photographed by K. Österlund). Measurements are rapid (within 1 s), and the resulting fluorescence parameters, as well as environmental conditions such as temperature, irradiance and depth, are stored in the Diving-PAM for later downloading to a PC for analysis. Using these parameters, rates of photosynthetic electron transport (ETR) can be calculated as



quantum yields (Y) multiplied with the photosynthetic photon flux (PPF) absorbed by the photosystem. If the latter is not known, or cannot be estimated, then relative ETRs can be calculated simply as Y times the incident PPF. Since respiration cannot be appraised by this method, it measures gross rather than net rates of photosynthesis. The diving-PAM also has an internal actinic (photosynthesis-producing) light source which enables rapid photosynthesis vs. irradiance (P-I) curves to be generated for pre-set irradiances (in addition to the *in situ* point measurements at ambient light). Such rapid light curves were recently presented for the *Prochloron* photosymbiont of a Great Barrier Reef ascidian (Schreiber et al. 1997), for stony coral zooxanthellae (Beer et al. 1998) and for cyanobacteria and zooxanthellae symbionts of reef sponges growing under low light conditions in the Red Sea (e.g. Fig 2 shows rapid light curves of three *Theonella swinhoei* individuals generated within minutes; from Beer and Ilan 1998). Thus, comparisons of photosynthetic performances can be achieved rapidly in ecologically relevant situations. Monitoring of such performances may serve to assess the general condition of these and similar organisms.

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Reef sites

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